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APPLICATION FOR LETTERS PATENT

TITLE: SIGNAL REPRODUCING METHOD & APPARATUS, SIGNAL
RECORDING/REPRODUCING METHOD AND APPARATUS AND
SIGNAL RECORDING MEDIUM

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BOOK REVIEW

Traditionally, a signal continuous in the time axis direction resulting from typically editing work such as an audio or video signal is recorded into a recording medium,

being split into segments as shown in Fig. 21 (1). In the figure, the symbol # on each of the segments indicates the order number in an operation to play back the signal. While the segments of the signal are arranged along a straight line as shown in the figure, the signal is actually recorded on a track having a spiral shape or concentric tracks on the recording medium.

Consider a playback operation in which segment #5 is reproduced after segment #4. In this case, a reproduced signal generated by a read pickup is broken due to a seek time, a rotation wait time and a settle time which are required between segments #4 and #5. The seek time is a period of time it takes to move the read pickup in a so-called track jump to a track in area where segment #5 is recorded. On the other hand, the rotation wait time is a period of time it takes to wait for the read pickup to arrive at the position of a target sector on the track. Finally, the settle time is a period of time it takes the tracking servo of the read pickup to get settled.

In order to prevent a playback signal eventually generated by the recording / playback apparatus from being broken even if the reproduced signal generated by the read pickup is unavoidably broken as described above, a read buffer memory is provided for storing in advance a signal

read out from the recording medium. The signal stored in the read buffer memory is used for filling up the time gap between two consecutive segments, that is, a period of time during which no reproduced signal is generated by the read pickup. The signal stored in the read buffer memory is then output when the reproduced signal generated by the read pickup is broken.

In the case of a recorded signal split into a large number of segments as shown in Fig. 21 (2), however, it is quite within the bounds of possibility that the amount of data stored in advance in the read buffer memory during the time is not large enough to be used for filling up a time gap between two consecutive segments. As a result, the eventual playback signal can not be generated continuously.

SUMMARY OF THE INVENTION

The present invention addresses the problems described above. It is thus an object of the present invention to provide a technology that makes a continuous playback operation possible by assuring that the amount of data stored in a read buffer memory is large enough for eliminating a playback time break through reduction of the number of seek operations.

In order to achieve the object of the present

[illegible]

newly allocating a continuous free area on the recording medium with a size of at least the equivalence of the predetermined recording / playback time length to the additional signal;

filling up the rest of the continuous free area
with a portion of the existing signal adjacent to the point
of insertion.

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provides a signal recording medium wherein a signal is recorded into continuous areas each having a size equal to or larger than a predetermined recording / playback time length.

According to one aspect of the present invention, there is provided a signal recording apparatus provided for recording a signal onto a recording medium wherein:

a 1st means is used for recognizing a continuous free area on the recording medium with a size equal to or larger than a predetermined recording / playback time length; and

a 2nd means is used for executing control to record a signal onto the continuous free area.

In addition, according to another aspect of the present invention, there is provided a signal recording / play back apparatus for recording and playing back a signal onto and from a recording medium wherein:

a 1st means is used for recognizing a continuous free area on the recording medium with a size equal to or larger than a predetermined recording / playback time length; and

a 3rd means is used for executing control to record a signal, which is supposed to be newly inserted into a point of insertion in an area on the recording

medium already occupied by an existing signal, onto the continuous free area and to fill up the rest of the continuous free area with a portion of the existing signal adjacent to the point of insertion.

On the top of that, according to a further aspect of the present invention, there is provided a signal recording / play back apparatus for recording and playing back a signal onto and from a recording medium wherein:

a 1st means is used for recognizing a continuous free area on the recording medium with a size equal to or larger than a predetermined recording / playback time length; and

a 4th means is used for executing control to relocate a continuous segment of a signal already recorded on the recording medium having a size smaller than a predetermined recording / playback time length and to fill up the rest of the continuous free area with a portion of the already recorded signal adjacent to the segment.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the present invention will be described by reference to the following diagrams wherein:

Fig. 1 is a block diagram showing the configuration of a signal recording / playback apparatus to which the present invention is applied;

Figs. 2 (1) and (2) are diagrams each showing a layout of a signal on a disc undergoing an operation to record an additional signal portion carried out by the signal recording / playback apparatus onto the disc;

Fig. 3 is a diagram showing locations of 3 programs recorded in 3 files on the disc with locations of each of the files represented by a straight line pattern;

Fig. 4 is a table showing an example of file system control information comprising entries to be referenced by a file system;

Fig. 5 shows an example of a FAT (File Allocation Table);

Fig. 6 is a diagram showing a technique for implementing control of a fixed rate to be achieved in a 1-minute period of time;

Fig. 7 is a block diagram showing the configuration of an apparatus implementing the fixed rate control;

Fig. 8 shows a flowchart representing an encoding process for implementing the fixed rate control;

Figs. 9 (1) to 9 (5) are diagrams showing layouts of a signal recorded on the disc of the signal recording / playback apparatus shown in Fig. 1 in an editing process;

Figs. 10 (1) and 10 (2) are diagrams showing general optimization of a signal;

Figs. 11 (1) to 11 (5) are diagrams showing general optimization of a signal carried out in the embodiment;

Fig. 12 is a diagram showing a signal to be edited in the embodiment;

Figs. 13 (1) to 13 (5) are diagrams showing examples of editing work carried out on a signal;

Figs. 14 (1) to 14 (5) are diagrams showing other examples of editing work carried out on a signal;

Figs. 15 (1) to 15 (4) are diagrams showing still other examples of editing work carried out on a signal;

Figs. 16 (1) to 16 (4) are diagrams showing further examples of editing work carried out on a signal;

Figs. 17 (1) to 17 (5) are diagrams showing still further examples of editing work carried out on a signal;

Figs. 18 (1) to 18 (3) are diagrams showing still further examples of editing work carried out on a signal;

Figs. 19 (1) to 19 (4) are diagrams showing still further examples of editing work carried out on a signal;

Figs. 20 (1) to 20 (3) are diagrams showing still further examples of editing work carried out on a signal;
and

Figs. 21 (1) and (2) are explanatory diagrams used for describing the ordinary method to play back a signal.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The above and other objects, features as well as many of the attendant advantages of the present invention will become more apparent and, thus, more readily appreciated as the same becomes better understood from a careful study of the following detailed description of a preferred embodiment of the present invention with reference to the accompanying diagrams. The description is divided into sections listed below which are explained sequentially in the order the sections are put on the following list:

1 Configuration of the Signal Recording / Playback Apparatus

2 Recording of an Additional Signal

3 Recognition of Free Areas

4 Editing

5 Optimization

6 Editing Details

1 Configuration of the Signal Recording / Playback Apparatus

Fig. 1 is a block diagram showing the configuration of a signal recording / playback apparatus to which the present invention is applied. The signal recording / playback apparatus records and plays back video and audio

signals into and from a solid memory represented by an optical magnetic disc, a magnetic disc, a magnetic tape and a semiconductor memory in addition to a data recording medium in general by multiplexing the signals. In order to simplify the description, however, only an optical magnetic disc which is referred to hereafter simply as a disc is explained as a representative.

In this signal recording / playback apparatus, a system controller 1 controls the apparatus as a whole in addition to carrying out other functions. A video encoder 2 performs a video encoding process on a video signal supplied thereto. By the same token, an audio encoder 3 carries out an audio encoding process on an audio signal supplied thereto. A multiplexer 4 multiplexes the outputs of the video and audio encoders 2 and 3. A write buffer memory 5 is used for temporarily storing the output of the multiplexer 4. A pickup 6 is used for writing the output of the write buffer memory 5 onto a disc. In addition, the pickup 6 is also used for reading out a playback signal from the disc and outputting the signal played back from the disc to a read buffer memory 7 which is used for temporarily storing the signal read out from the disc by the pickup 6. A demultiplexer 8 splits the output of the read buffer memory 7 back into video and audio data. A

video decoder 9 carries out a video decoding process on the video data resulting from the split done by the demultiplexer 8. By the same token, an audio decoder 10 carries out an audio decoding process on the audio data resulting from the split done by the demultiplexer 8.

2 Recording of an Additional Signal

Figs. 2 (1) and (2) are diagrams each showing recording a layout of a signal on a disc undergoing an operation to record an additional signal portion by the signal recording / playback apparatus onto the disc. To be more specific, Fig. 2 (1) is a diagram showing a recording layout prior to the additional recording operation and Fig. 2 (2) is a diagram showing a recording layout after the additional recording operation. In the figures, a portion shown as a thin mesh denotes an area in which the signal is recorded. As shown in the figure, an additional signal is not split into segments to be each recorded into a free area with a length smaller than a predetermined value, typically an equivalent of the 1-minute recording / playback time length. Instead, the additional signal is recorded into a continuous free area with a length equal to or larger than the 1-minute recording / playback time length.

3 Determination of Free Areas

This section explains a means for recognizing a continuous free area of at least the predetermined typical value, that is, an equivalent of the 1-minute recording / playback time length in length.

(a) Means for recognizing free areas

Information on files on the disc is all recorded in a TOC (Table of Contents) area. At the time the disc is mounted on the signal recording / playback apparatus, the system controller 1 reads out this information on files from the TOC area and controls the files on the disc till the disc is taken out from the apparatus. In order to control files on the disc, the system controller 1 is provided with a FAT (File Allocation Table) 11. The location and attributes such as the number, the recording date & time and the file name of each file on the disc are controlled by referencing the FAT 11. The FAT 11 is used for controlling the information on files in smallest access units, typically sector units, used by the system, that is, the signal recording / playback apparatus for making an access to the disc. It should be noted that, in this embodiment, 1 sector is 2,048 bytes (or 2K bytes) in size.

stored in the file), a recording date & time, a recording channel, a recording time and a first sector of the file as shown in the figure. When an access is made to a file, the file system refers to the entry for the file and starts the access. It is needless to say that other file attribute information can be added to the table.

Fig. 5 shows an example of the FAT 11. The example is a table for data of a program which is not recorded in physically consecutive sectors on the disc. In this case, for each sector storing the data, the number of a next sector for storing the same data is recorded. In order to make the table shown in the figure easy to understand, a free area is represented by blanks. In actuality, however, the free area is filled up with codes "000". The end of a file is indicated by a code "fff". Thus, a free area is found by sequentially scanning the left column of the FAT starting from sector 000 and ending at a sector with the next sector thereof on the right column having a blank ("000") sector number. The size of a free area is found by counting the numbers of physically consecutive sectors included in the free area.

(b) Searching for a free area with a size greater than an equivalent of the 1-minute recording / playback time length

There are 4 methods which can be adopted by the file system for forming a judgment as to whether or not the size of a physically continuous free area is at least an equivalent of the 1-minute recording / playback time length.

According to a 1st method, the judgment is formed by determining whether or not the free area can be used for accommodating data recorded for a period of time of at least 1 minute at the maximum recording rate. According to a 2nd method, the amount of data recorded for a 1-minute period of time is first calculated by assuming a fixed recording rate in each measurement time unit. The recording rate may vary from unit to unit. It should be noted, however that, since the measurement time unit itself is also typically 1 minute in length anyway, in actuality, the recording rate can be assumed to be fixed during the 1-minute period of time. The judgment is then formed by comparing the calculated amount of data with the size of the free area. According to a 3rd method, the judgment is formed by simply determining whether or not the size of the free area is greater than a predetermined amount of data typically expressed in terms of bytes instead of the amount of data recorded for a 1-minute measurement time used in the 2nd method. According to a 4th method, the amount of

data recorded for a 1-minute period of time is first calculated by assuming a fixed recording rate during the 1-minute period of time. In this case, the amount of data resulting from the calculation is also fixed. The judgment is then formed by comparing the calculated amount of data with the size of the free area. The 2nd method, a representative one among the 4 methods, is explained as follows.

In order to implement a fixed recording rate (that is, a fixed encoding bit rate) during the 1-minute period of time prescribed by the 2nd method, it is necessary to execute control so that the number of bits generated by the video encoder which is typically implemented by an MPEG2 encoder in 1 minute is constant.

A degree of difficulty of carrying out video encoding on a picture is defined as a product of the number of generated bits and an average quantization width in 1 picture. In the so-called variable rate encoding process, the number of generated bits is adjusted as follows. In the case of a picture requiring video encoding at a high degree of difficulty, encoding needs to be carried out at an encoding bit rate greater than the past average bit rate to allocate a number of generated bits larger than what would be obtained at the average bit rate in the past to a

other parameters such as the range ALPHA are set.

The flow of the encoding process then goes on to a step S2 to form a judgment as to whether or not a signal being input is the head of a GOP (Group of Pictures). If the head of a GOP is input, the flow of the encoding process proceeds to a step S3 at which the amount of generated code for an I picture is computed. Then, the flow of the encoding process continues to a step S4 at which the number of allocated bits is computed and the quantization width is adjusted to a value between the maximum and minimum encoding bit rates. In addition, a quantization table is created. Subsequently, the flow of the encoding process goes on to a step S5 at which all macroblocks of a picture are encoded. The flow then proceeds to a step S6 at which the number of generated bits is counted. The number of generated bits is used in the adjustment of the quantization width carried out at the step S4. If the outcome of the judgment formed at the step S2 indicates that the input signal is not the head of a GOP, on the other hand, the flow of the encoding process continues directly to the step S5.

In the encoding process described above, the quantization width is determined so that the actual amount of generated code can be brought to a value all but equal

SECRET

4 Editing

Figs. 9 (1) to 9 (5) are diagrams showing layouts of a signal recorded on the disc of the signal recording / playback apparatus shown in Fig. 1 in a typical editing process.

In this typical editing process, assume that portion #2 with a length of smaller than the 1-minute recording / playback time length is moved from its original position in a signal shown in Fig. 9 (1) to a point of insertion indicated by an arrow by insertion. As the process to rewrite the signal due to the insertion of portion #2 is completed, the new layout of the signal is changed to that shown in Fig. 9 (2). In the insertion, the process to rewrite portion #1 of the signal behind the point of insertion takes a lot of time and labor.

In order to solve the problem described above, the signal is edited from a layout shown in Fig. 9 (3) to a

layout shown in Fig. 9 (4). To put it in detail, a continuous free area with a length equal to or larger than the 1-minute recording / playback time length on the disc is allocated. In the free area, portion #2 and a part in portion #1 in front of the point of insertion shown in Fig. 9 (1) on the time axis are written into the free area to fill up the free area, resulting in the layout shown in Fig. 9 (4). Assume that the free area is an equivalent of the 1-minute recording / playback time length in length as shown in the layout of Fig. 9 (3). In this case, the length of the part of portion #1 moved to the free area, that is, the length of area A shown in Fig. 9 (4), is equal to (the length corresponding to a recording time of 1 minute - the length of portion #2). As a result of the work to edit the signal from the layout shown in Fig. 9 (3) to that shown in Fig. 9 (4), the resulting continuous blocks each have a length greater than an equivalent of the 1-minute recording / playback time length. Thus, seek operations are carried out at intervals longer than 1 minute, providing a period of time between two consecutive seek operations which is long enough for filling the read buffer memory with data of an amount sufficiently large to be output during a track jump. As a result, a playback operation can be carried out without a playback time break.

It should be noted that #1, #2, #3 and #4 in the layout shown in Fig. 9 (5) are consecutive numbers in the time axis direction which correspond respectively to #1 at the left end, #1 and #2 at the right end, #1 in the middle and #3 in the layout shown in Fig. 9 (4).

In the work to edit the signal from the layout shown in Fig. 9 (3) to that shown in Fig. 9 (4) described above, area A, the data of which is moved to the free area, is located in front of the point of insertion. It should be noted that, however, area A can be located behind the point of insertion. In this case, the data of area A is moved to a location in the free area behind portion #2. As an alternative, area A can comprise 2 sub-areas sandwiching the point of insertion. In this case, portion #2 in the free area is sandwiched by 2 pieces of data moved from the 2 sub-areas of area A respectively.

5 Optimization

Consider a case in which segments #1 to #16 of a signal recorded on the disc are consecutive in the time axis direction but not recorded at physically continuous areas as shown in Fig. 10 (1). The segments can be rearranged in a so-called defragmentation process so that they are recorded at physically continuous areas as shown

in Fig. 10 (2). In this case, however, it takes a very long time to rearrange the segments as such and the rearrangement can not be the to be always practical.

In order to solve the problem described above, in this embodiment, only segments each with a length of smaller than the 1-minute recording / playback time length recorded in scattered areas are treated as a target of rearrangement in order to make all continuous blocks of the signal at least the equivalent of the 1-minute recording / playback time length in size. Consider, for example, a signal with only segment #3 having a length of smaller than the 1-minute recording / playback time length as shown in Fig. 11 (1). In this case, first of all, a free area with a size of an equivalent of the 1-minute recording / playback time length is allocated and segment #3 is moved thereto to result in a layout shown in Fig. 11 (2). Then, a portion at the head of segment #4 with a length equal to (a length corresponding to the equivalent of the 1-minute recording / playback time length - the length of segment #3) is cut out and moved to the free area behind segment #3 as shown in Fig. 11 (3) to fill up the free area, resulting in a layout shown in Fig. 11 (4). Finally, the segment numbers are revised into consecutive numbers arranged in an ascending order in the time axis direction to result in a

layout shown in Fig. 11 (5). As shown in Fig. 11 (5), the resulting continuous blocks of the signal at their physical locations on the disc each have a length greater than the equivalent of the 1-minute recording / playback time length with the playback order remaining unchanged. Thus, the number of seek operations is reduced, allowing a playback operation to be carried out smoothly. In this way, a file of a signal on the disc can be optimized with ease.

6 Editing Details

Next, the editing technique shown in Fig. 9 is explained in detail. Fig. 12 is a diagram showing a signal to be edited in the embodiment. As shown in the figure, segments A, C1, C2 and C3 constitute a continuous sequence of data. Assume that segment B is inserted between segments A and C1. Let symbols a, c1, b, c2 and c3 denote the lengths of segment A, C1, B, C2 and C3 respectively. Editing technique applied to a variety of cases are explained as follows.

A Lengths a and b equal to or larger than the 1-minute recording / playback time length

Fig. 13 (1) is a diagram showing a case in which segment B to be inserted completes the data at segment C1.

Since segments C2 and C3 of the signal shown in Fig. 12 do not exist, segment B is merely inserted between segments A and C1. However, it is not necessary to physically move segments B and C1. What needs to be done is just changing the playback pointers to A --> B --> C1. In this case, since segment C1 is the segment to be played back last, there is no triggered seek operation after segment C1. Thus, the length c1 of segment C1 can be smaller than 1 minute of playback time.

Fig. 13 (2) is a diagram showing a case in which the data continues to segment C3. Even in this case, segment B is just inserted between segments A and C1 provided that the length c1 of segment C1 is at least an equivalent of the 1-minute recording / playback time length. That is to say, by merely changing the playback pointers from A --> C1 --> C2 --> C3 to A --> B --> C1 --> C2 --> C3, insertion on the time axis is completed without the need to physically insert segment B between segments A and C1. In this case, the length c2 of segment C2 must be of course at least an equivalent of the 1-minute recording / playback time length as is the case with the length c1 of segment C1. To be played back last, however, the length c3 of segment C3 can be smaller than the 1-minute recording / playback time length.

allocated free area to fill up the area.

It should be noted that, if a free area having a size of at least an equivalent of the 1-minute recording / playback time length can not be allocated, the editing can not be done and is thus ended unsuccessfully.

By physically relocating the lump of data in the editing technique described above, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated provided that the remaining part of segment C2 denoted by notation "C2 - (2)" in the figure after removing the portion at the head of segment C2 denoted by notation "C2 - (1)" is at least an equivalent of the 1-minute recording / playback time length in size. In this case, the editing work is completed successfully.

If the remaining part of segment C2 denoted by notation "C2 - (2)" is smaller an equivalent of the 1-minute recording / playback time length in size, however, the amount of data stored temporarily stored in the read buffer memory to be output as a playback signal during a seek operation accompanying a track jump from the remaining part of segment C2 denoted by notation "C2 - (2)" to segment C3 will be smaller than the 1-minute recording /

playback time length. In order to solve this problem caused by the small length of the remaining part denoted by notation "C2 - (2)" of segment C2, the data is edited by adopting a technique shown in Fig. 13 (5), a diagram showing an editing technique which comprises the steps of:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length behind the relocated portion at the head of segment C2 denoted by notation "C2 - (1)";

concatenating the remaining part of segment C2 denoted by notation "C2 - (2)" with a portion at the head of segment C3 denoted by notation "C3 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

By physically relocating the lump of data in the editing technique described above, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated. It should be noted that, if a free area having a size of at least an equivalent of the 1-minute recording / playback time length can not be allocated behind the relocated portion at the

head of segment C2 denoted by notation "C2 - (1)", the area originally occupied by segment C2 with a guaranteed size equal to or larger than the 1-minute recording / playback time length can be used as a free area.

The editing technique shown in Fig. 13 (5) can be applied to subsequent segments C4 and C5 if they exist after segment C3.

B Length a of smaller than the 1-minute recording / playback time length and length b equal to or larger than the 1-minute recording / playback time length

In this case, if segment B is merely inserted between segments A and C1, the amount of data temporarily stored in the read buffer memory during an operation to playback segment A having a length smaller than the 1-minute recording / playback time length will not be large enough to be used as an output playback signal during a seek operation accompanying a track jump from segment A to segment B following the operation to playback segment A in the playback operation. In order to solve this problem caused by the small length a of segment A, the data is edited by adopting a technique shown in Fig. 14 (2), a diagram showing an editing technique which comprises the steps of:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

concatenating segment A with a portion at the head of segment B denoted by notation "B - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

It should be noted that, if a free area having a size of at least an equivalent of the 1-minute recording / playback time length can not be allocated, the editing can not be done and is thus ended unsuccessfully.

By physically relocating the lump of data in the editing technique described above, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated provided that the remaining part of segment B denoted by notation "B - (2)" in the figure after removing the portion at the head of segment B denoted by notation "B - (1)", that is a length $\{b - (1 - a)\}$, is at least an equivalent of the 1-minute recording / playback time length in size. In this case, the editing work is completed successfully. It is thus

necessary to form a judgment as to whether or not the length $\{b - (1 - a)\}$ is at least an equivalent of the 1-minute recording / playback time length or a length $(a + b)$ is at least an equivalent of the 2-minute recording / playback time length.

If $(a + b)$ is at least an equivalent of the 2-minute recording / playback time length in size, the amount of data temporarily stored in the read buffer memory during an operation to playback the remaining part of segment B denoted by notation "B - (2)" will be large enough to be used as an output playback signal during a seek operation accompanying a track jump from the remaining part of segment B to segment C1 following the operation to playback the remaining part of segment B in the playback operation. Then, it is necessary to form a judgment as to whether or not the length $c1$ of segment C1 is at least an equivalent of the 1-minute recording / playback time length, or whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the

problem caused by the small length c1 segment C1 can be solved by applying a method similar to the editing technique shown in Figs. 13 (3) to (5) of Subsection A with the title "Lengths a and b equal to or larger than the 1-minute recording / playback time length" described above.

To put it in detail, if $(a + b)$ is smaller than the 2-minute recording / playback time length in size, the problem caused by the small length of the remaining part denoted by notation "B - (2)" of segment B is solved by applying an editing technique shown in Fig. 14 (3), a diagram showing an editing technique of forming a judgment as to whether a free area having a size equal to or larger than the 1-minute recording / playback time length can be allocated. If such an area can be allocated, the formation of the judgment is followed by the steps of:

allocating the free area;

concatenating the remaining part of segment B denoted by notation "B - (2)" with a portion at the head of segment C1 denoted by notation "C1 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

If such a free area can not be allocated, on the

other hand, the lump area is relocated to the area used to be occupied by segment B. In either case, segment B and segment C are fragmented.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length $(a + b + c_1 - 2)$ of the remaining part denoted by notation " $C_1 - (2)$ " of segment C_1 after removing the portion denoted by notation " $C_1 - (1)$ " is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation " $C_1 - (2)$ " of segment C_1 is the last portion of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the small length of the remaining part denoted by notation " $C_1 - (2)$ " of segment C_1 can be solved by applying an editing technique shown in Fig. 14 (4), a diagram showing an editing technique which comprises the steps of:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time

length;

concatenating the remaining part of segment C1 denoted by notation "C1 - (2)" with a portion at the head of segment C2 denoted by notation "C2 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "C2 - (2)" of segment C2 after removing the portion denoted by notation "C2 - (1)" is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation "C2 - (2)" of segment C1 is the last portion of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the small length of the remaining part denoted by notation "C2 - (2)" of segment C2 can be solved by applying an editing

1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062 1063 1064 1065 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077 1078 1079 1080 1081 1082 1083 1084 1085 1086 1087 1088 1089 1090 1091 1092 1093 1094 1095 1096 1097 1098 1099 1100 1101 1102 1103 1104 1105 1106 1107 1108 1109 1110 1111 1112 1113 1114 1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127 1128 1129 1130 1131 1132 1133 1134 1135 1136 1137 1138 1139 1140 1141 1142 1143 1144 1145 1146 1147 1148 1149 1150 1151 1152 1153 1154 1155 1156 1157 1158 1159 1160 1161 1162 1163 1164 1165 1166 1167 1168 1169 1170 1171 1172 1173 1174 1175 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185 1186 1187 1188 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199 1200 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214 1215 1216 1217 1218 1219 1220 1221 1222 1223 1224 1225 1226 1227 1228 1229 1230 1231 1232 1233 1234 1235 1236 1237 1238 1239 1240 1241 1242 1243 1244 1245 1246 1247 1248 1249 1250 1251 1252 1253 1254 1255 1256 1257 1258 1259 1260 1261 1262 1263 1264 1265 1266 1267 1268 1269 1270 1271 1272 1273 1274 1275 1276 1277 1278 1279 1280 1281 1282 1283 1284 1285 1286 1287 1288 1289 1290 1291 1292 1293 1294 1295 1296 1297 1298 1299 1300 1301 1302 1303 1304 1305 1306 1307 1308 1309 1310 1311 1312 1313 1314 1315 1316 1317 1318 1319 1320 1321 1322 1323 1324 1325 1326 1327 1328 1329 1330 1331 1332 1333 1334 1335 1336 1337 1338 1339 1340 1341 1342 1343 1344 1345 1346 1347 1348 1349 1350 1351 1352 1353 1354 1355 1356 1357 1358 1359 1360 1361 1362 1363 1364 1365 1366 1367 1368 1369 1370 1371 1372 1373 1374 1375 1376 1377 1378 1379 1380 1381 1382 1383 1384 1385 1386 1387 1388 1389 1390 1391 1392 1393 1394 1395 1396 1397 1398 1399 1400 1401 1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412 1413 1414 1415 1416 1417 1418 1419 1420 1421 1422 1423 1424 1425 1426 1427 1428 1429 1430 1431 1432 1433 1434 1435 1436 1437 1438 1439 1440 1441 1442 1443 1444 1445 1446 1447 1448 1449 1450 1451 1452 1453 1454 1455 1456 1457 1458 1459 1460 1461 1462 1463 1464 1465 1466 1467 1468 1469 1470 1471 1472 1473 1474 1475 1476 1477 1478 1479 1480 1481 1482 1483 1484 1485 1486 1487 1488 1489 1490 1491 1492 1493 1494 1495 1496 1497 1498 1499 1500 1501 1502 1503 1504 1505 1506 1507 1508 1509 1510 1511 1512 1513 1514 1515 1516 1517 1518 1519 1520 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531 1532 1533 1534 1535 1536 1537 1538 1539 1540 1541 1542 1543 1544 1545 1546 1547 1548 1549 1550 1551 1552 1553 1554 1555 1556 1557 1558 1559 1560 1561 1562 1563 1564 1565 1566 1567 1568 1569 1570 1571 1572 1573 1574 1575 1576 1577 1578 1579 1580 1581 1582 1583 1584 1585 1586 1587 1588 1589 1590 1591 1592 1593 1594 1595 1596 1597 1598 1599 1600 1601 1602 1603 1604 1605 1606 1607 1608 1609 1610 1611 1612 1613 1614 1615 1616 1617 1618 1619 1620 1621 1622 1623 1624 1625 1626 1627 1628 1629 1630 1631 1632 1633 1634 1635 1636 1637 1638 1639 1640 1641 1642 1643 1644 1645 1646 1647 1648 1649 1650 1651 1652 1653 1654 1655 1656 1657 1658 1659 1660 1661 1662 1663 1664 1665 1666 1667 1668 1669 1670 1671 1672 1673 1674 1675 1676 1677 1678 1679 1680 1681 1682 1683 1684 1685 1686 1687 1688 1689 1690 1691 1692 1693 1694 1695 1696 1697 1698 1699 1700 1701 1702 1703 1704 1705 1706 1707 1708 1709 1710 1711 1712 1713 1714 1715 1716 1717 1718 1719 1720 1721 1722 1723 1724 1725 1726 1727 1728 1729 1730 1731 1732 1733 1734 1735 1736 1737 1738 1739 1740 1741 1742 1743 1744 1745 1746 1747 1748 1749 1750 1751 1752 1753 1754 1755 1756 1757 1758 1759 1760 1761 1762 1763 1764 1765 1766 1767 1768 1769 1770 1771 1772 1773 1774 1775 1776 1777 1778 1779 1780 1781 1782 1783 1784 1785 1786 1787 1788 1789 1790 1791 1792 1793 1794 1795 1796 1797 1798 1799 1800 1801 1802 1803 1804 1805 1806 1807 1808 1809 1810 1811 1812 1813 1814 1815 1816 1817 1818 1819 1820 1821 1822 1823 1824 1825 1826 1827 1828 1829

concatenating the remaining part of segment C2 denoted by notation "C2 - (2)" with a portion at the head of segment C3 denoted by notation "C3 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

C Length a equal to or larger than the 1-minute recording / playback time length and length b smaller than the 1-minute recording / playback time length

allocating a free area having a size of $(1 - b)$
right behind segment B; and

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Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

physically relocating the lump of data to the allocated free area to fill up the area.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "C1 - (2)" of segment C1 after removing the portion denoted by notation "C1 - (1)" is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation "C1 - (2)" of segment C1 is the last portion of the data, that is,

whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the small length of the remaining part denoted by notation "C1 - (2)" of segment C1 can be solved by applying editing techniques shown in Figs. 15 (3) and 15 (4) which are similar to those shown in Figs. 13 (4) and 13 (5) described earlier respectively.

D Both lengths a and b smaller than the 1-minute recording / playback time length

In this case, editing work for a total length (a + b) equal to or larger than the 1-minute recording / playback time length is different from that for a total length (a + b) smaller than the 1-minute recording / playback time length. The following description begins with a case shown in Fig. 16 (1) in which the total length (a + b) is smaller than the 1-minute recording / playback time length. The case requires a technique shown in Fig. 16 (2), a diagram showing an editing technique which

comprises:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

concatenating segments A and B with a portion at the head of segment C1 denoted by notation "C1 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

As an alternative, the editing technique may comprise the steps of:

allocating a free area having a size of $(1 - b)$ right behind segment B; and

physically relocating a portion at the head of segment C1 denoted by notation "C1 - (1)" in the figure to fill up the free area.

It should be noted that, if a free area having a size of at least an equivalent of the 1-minute recording / playback time length can not be allocated in either case, the editing can not be done and is thus ended unsuccessfully.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the

length of the remaining part denoted by notation "C1 - (2)" of segment C1 after removing the portion denoted by notation "C1 - (1)" is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation "C1 - (2)" of segment C1 is the last portion of the data, that is, whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the short length of the remaining part denoted by notation "C1 - (2)" of segment C1 can be solved by applying an editing techniques shown in Figs. 16 (3) and 16 (4) which are similar to those shown in Figs. 13 (4) and 13 (5) described earlier respectively.

The following is description of a case shown in Fig. 17 (1) in which the total length (a + b) is at least an equivalent of the 1-minute recording / playback time length. In this case, it is necessary to apply a technique shown in Fig. 17 (2), a diagram showing an editing technique which comprises:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

concatenating segment A with a portion at the head of segment B denoted by notation "B - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

It should be noted that, if a free area having a size of at least an equivalent of the 1-minute recording / playback time length can not be allocated in either case, the editing can not be done and is thus ended unsuccessfully.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "C1 - (2)" of segment C1 after removing the portion denoted by notation "C1 - (1)" is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation "C1 - (2)" of segment C1 is the last portion of the data, that is, whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation

following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the short length of the remaining part denoted by notation "C1 - (2)" of segment C1 can be solved by applying an editing techniques shown in Figs. 17 (4) and 17 (5) which are similar to those shown in Figs. 13 (4) and 13 (5) described earlier respectively.

In the cases discussed in subsections A to D, segment B to be inserted is recorded in one continuous area. The following subsections describe cases in which segment B comprises sub-segments B1, B2 and B3 which are recorded in areas physically separated from each other. It is assumed that, as a single segment, there is an assurance that data of segment B can be reproduced without generating a playback time break caused by a seek operation which is in turn attributed to a track jump. That is to say, sub-segments B1 and B2 each have a length equal to or larger than the 1-minute recording / playback time length. To be played back last, on the other hand, sub-segment B3 can be at least or smaller than the 1-minute recording / playback time length in size.

E Both lengths a and b ($= b1 + b2 + b3$) equal to or larger than the 1-minute recording / playback time length

Processing for a case in which sub-segment B3 has a length b3 equal to or larger than the 1-minute recording / playback time length is different from a case with the length b3 smaller than the 1-minute recording / playback time length. In the former case shown in Fig. 18 (1), it is necessary to form a judgment as to whether or not the length c1 of segment C1 is at least an equivalent of the 1-minute recording / playback time length or whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully by merely correcting the playback pointers. If both the conditions are not satisfied, on the other hand, the problem caused by the short length of segment C1 can be solved by applying an editing techniques shown in Figs. 18 (2) and 18 (3) which are similar to those shown in Figs. 13 (4) and 13 (5) described earlier respectively.

Fig. 19 (1) is a diagram showing a case in which

the length b3 of sub-segment B3 is smaller than the 1-minute recording / playback time length. In this case, it is necessary to apply a technique shown in Fig. 19 (2), a diagram showing an editing technique which comprises:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

concatenating sub-segment B3 with a portion at the head of segment C1 denoted by notation "C1 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "C1 - (2)" of segment C1 after removing the portion denoted by notation "C1 - (1)" is at least an equivalent of the 1-minute recording / playback time length, or whether or not the remaining part denoted by notation "C1 - (2)" of segment C1 is the last portion of the data, that is, whether or not segment C1 is the last segment of the data. If either of the conditions is satisfied, a seek operation following an operation to play back a continuous segment

having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If both the conditions are not satisfied, on the other hand, the problem caused by the short length of the remaining part denoted by notation "C1 - (2)" of segment C1 can be solved by applying an editing techniques shown in Figs. 19 (3) and 19 (4) which are similar to those shown in Figs. 13 (4) and 13 (5) described earlier respectively.

F Length a of smaller than the 1-minute recording / playback time length and length b ($= b_1 + b_2 + b_3$) equal to or larger than the 1-minute recording / playback time length

Fig. 20 (1) is a diagram showing a case in which the length a is smaller than the 1-minute recording / playback time length and the length b ($= b_1 + b_2 + b_3$) is at least an equivalent of the 1-minute recording / playback time length. In this case, it is necessary to apply a technique shown in Fig. 20 (2), a diagram showing an editing technique which comprises:

allocating a free area having a size of at least an equivalent of the 1-minute recording / playback time length;

concatenating segment A with a portion at the head of sub-segment B1 denoted by notation "B1 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "B1 - (2)" of sub-segment B1 after removing the portion denoted by notation "B1 - (1)" is at least an equivalent of the 1-minute recording / playback time length. If the remaining part denoted by notation "B1 - (2)" of sub-segment B1 is at least an equivalent of the 1-minute recording / playback time length in length, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If the remaining part denoted by notation "B1 - (2)" of sub-segment B1 is smaller than the 1-minute recording / playback time length in length, on the other hand, it is necessary to apply a technique shown in Fig. 20 (3), a diagram showing an editing technique which comprises:

allocating a free area having a size equal to or larger than the 1-minute recording / playback time length; concatenating the remaining part denoted by notation "B1 - (2)" of sub-segment B1 with a portion at the head of sub-segment B2 denoted by notation "B2 - (1)" in the figure to form a lump of data having a size equal to that of the allocated free area; and

physically relocating the lump of data to the allocated free area to fill up the area.

After the lump of data has been relocated, it is necessary to form a judgment as to whether or not the length of the remaining part denoted by notation "B2 - (2)" of sub-segment B2 after removing the portion denoted by notation "B2 - (1)" is at least an equivalent of the 1-minute recording / playback time length. If the remaining part denoted by notation "B2 - (2)" of sub-segment B2 is at least an equivalent of the 1-minute recording / playback time length in length, a seek operation following an operation to play back a continuous segment having a size smaller than the 1-minute recording / playback time length can be eliminated in which case, the editing work is completed successfully. If the remaining part denoted by notation "B2 - (2)" of sub-segment B1 is smaller than the 1-minute recording / playback time length in length, on the

other hand, it is necessary to repeat the processing described above for the remaining part denoted by notation "B2 - (2)" of sub-segment B2 and sub-segment B3.

In the editing techniques described above, the minimum size of a continuous segment is set at a value equivalent to the 1-minute recording / playback time length. It should be noted that this value can be changed depending on the seek time, the rotation wait time and the settle time of the signal playback apparatus. For example, the minimum size of a continuous segment is set at a multiple or a fraction of the equivalent of the 1-minute recording / playback time length. In addition, the minimum size of a continuous segment can be set in dependence on factors other than the time related parameters. To be more specific, the minimum size of a continuous segment can be set at an equivalence of a predetermined amount of data, the GOP unit used in the MPEG encoding process or a data unit used in internal processing such a packet or a block.

As described in detail above, according to the present invention, the amount of data stored in advance in the read buffer memory during the time is large enough to eliminate a next playback time break, that is, to be output during a next track jump in a seek operation entailing not only a seek time, but also a rotation wait time and a

settle time. As a result, the eventual playback signal can be generated continuously. In addition, the time it takes to optimize data recorded in the disc by defragmentation of the data can be reduced substantially.

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